Annual research report

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Outline

- Introduction to the Fermilab accelerator & CDF detector
- Service work
- Why τ is interesting
- τ properties
- Monte Carlo Study of τ
- Plan for the next year

The Fermilab accelerator and CDF detector

- Accelerator (Tevatron)

  synchrocyclotron collider

  4 miles in circumference

  $E_{CM} = 2.0$ TeV (highest energy in the world)

- CDF (Collider Detector at Fermilab)

  detect momentum and energy of particles

  identify particles

  Tracking : SVXII, ISL, COT

  Calorimeter : SHX, ECL, HCL

  Muon : CMX, CMU, CMP

  Timing : TOF

Figure 1: Fermi National Accelerator Laboratory at Batavia, IL

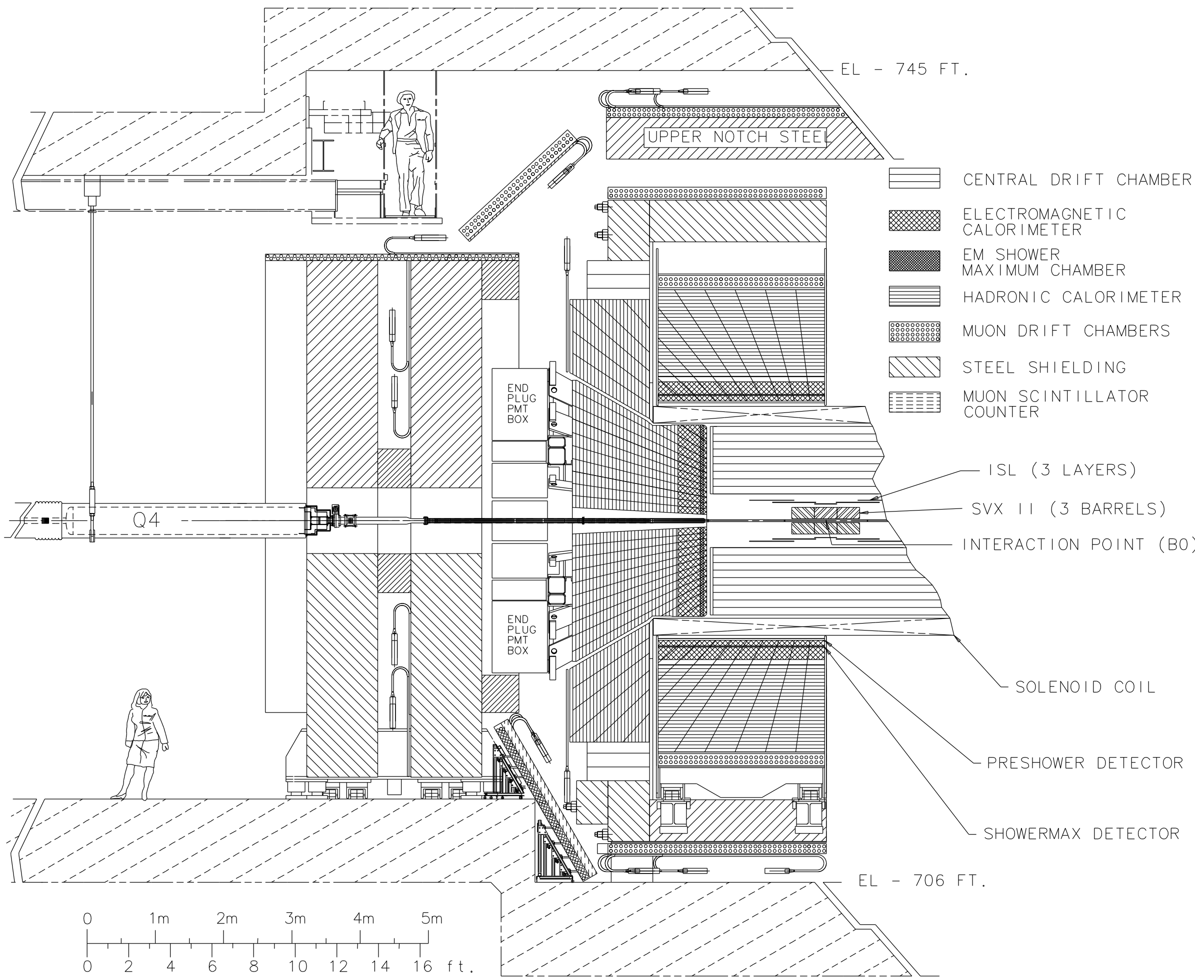


Figure 2: Elevation view of half of CDF detector

Service work

- Silicon Visual Inspection

  Looking for flaws on silicon chip

  Work with techinician

  Learned a lot of SVX hardware

- Software development for CDF (EventMerge)

  What? : Overlay one data to another

  Usage : Usually merge minimum biased data onto MC

  Purpose : Make MC more realistic

  Operation : COT, Muon using TDC information

  Work with : Todd Huffman from Oxford

  RunI : This project had never been used

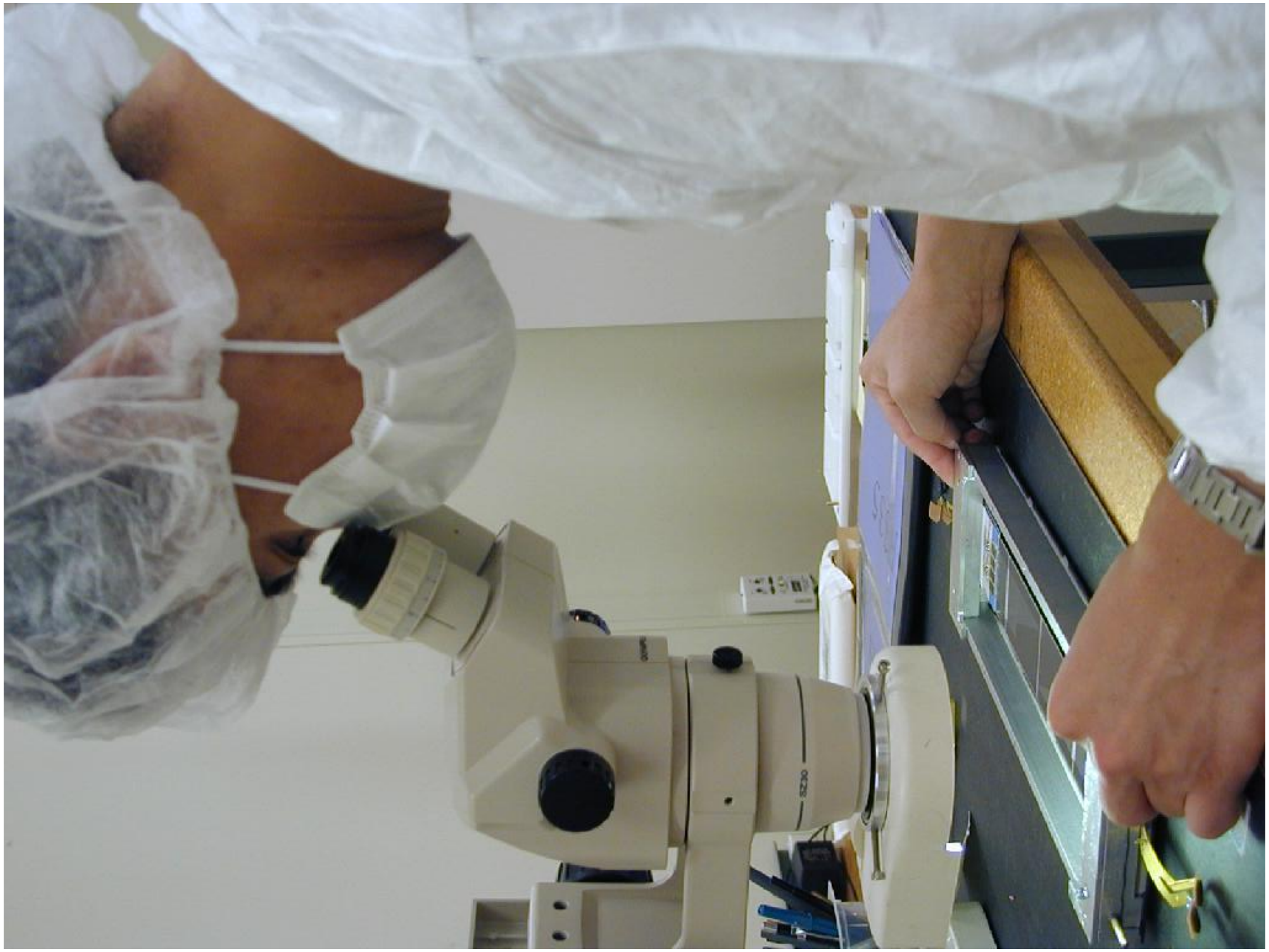


Figure 3: Optical inspection for SVX layer 4 ladder

Why τ is interesting

- Physics Groups at CDF

  Groups : B , Electroweak, QCD, Top, Exotics.

  Rutgers group : heavily involved in Exotics to search on Higgs and SUSY.

- Interesting channels with τ's

  $p\bar{p} \to H(W^{\pm}, Z^0)$ with $H \to \tau\bar{\tau}$

  $p\bar{p} \to Hb\bar{b}$ with $H \to \tau\bar{\tau}$

  $p\bar{p} \to H_{SM}$ with $H \to \tau\bar{\tau}$

  SUSY partner of τ, $\tilde{\tau}$

τ properties

- Basic properties

  Spin : J $= \frac{1}{2}$

  Mass : $m_\tau = 1.78 GeV$

  Mean lifetime : 2.9×10^{-17}s ($c\tau = 87.11\mu m$)

  BR($\tau \to e\bar{\nu}_e\nu_\tau$) = 17.83%

  BR($\tau \to \mu\bar{\nu}_\mu\nu_\tau$) = 17.37%

  BR($\tau \to hadrons$) = 64.80%

  BR($\tau \to$ hadron's 1-prong) = 49.51%

  BR($\tau \to$ hadron's 3-prong) = 15.18%

τ properties

- Signatures in detector

  Many decay channels

  Always carries ν, which contributes missing energy

  Hard to identify leptonic channels in detector

  Similar to jets

  So interesting, but difficult.

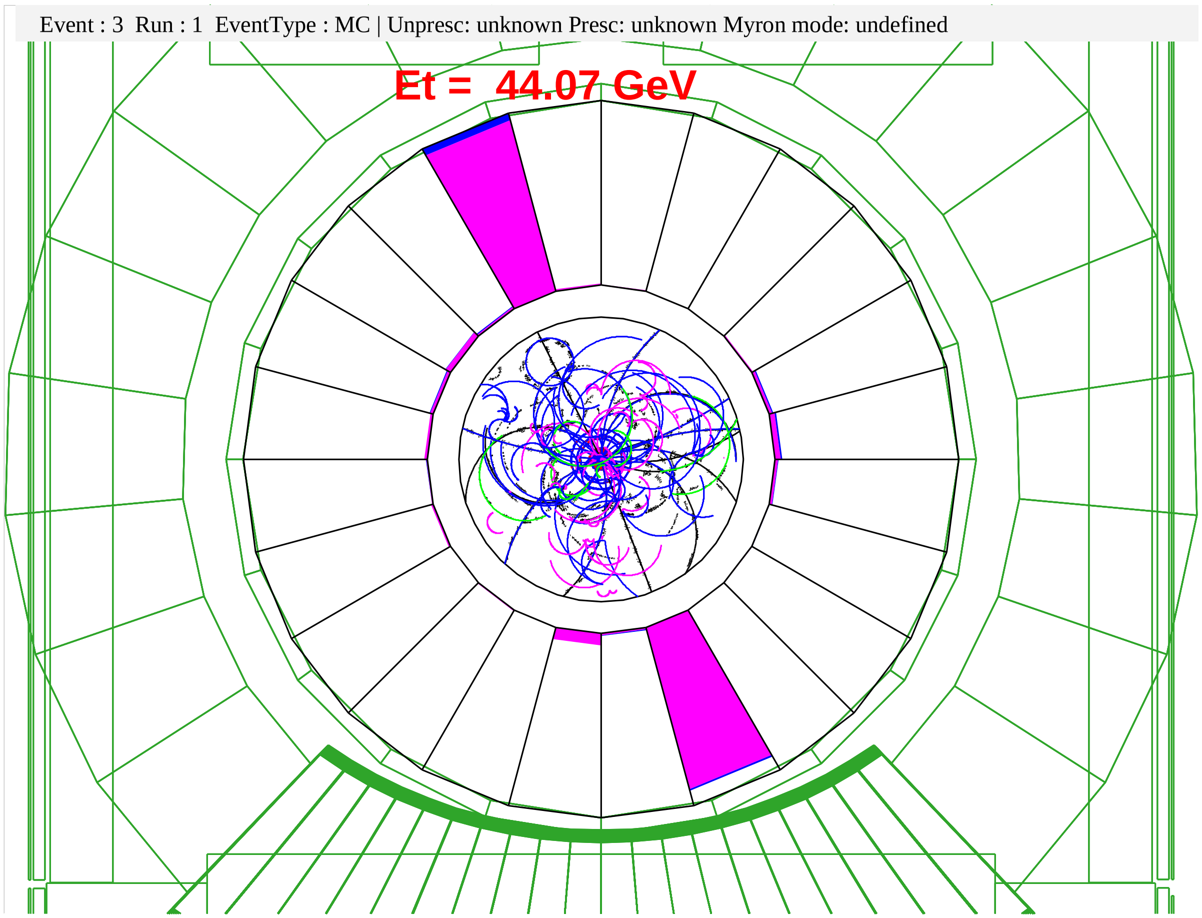


Figure 4: Z $\rightarrow e^+e^-$ decay, MC sample generated by Pythia generator. Thanks to Greg V.

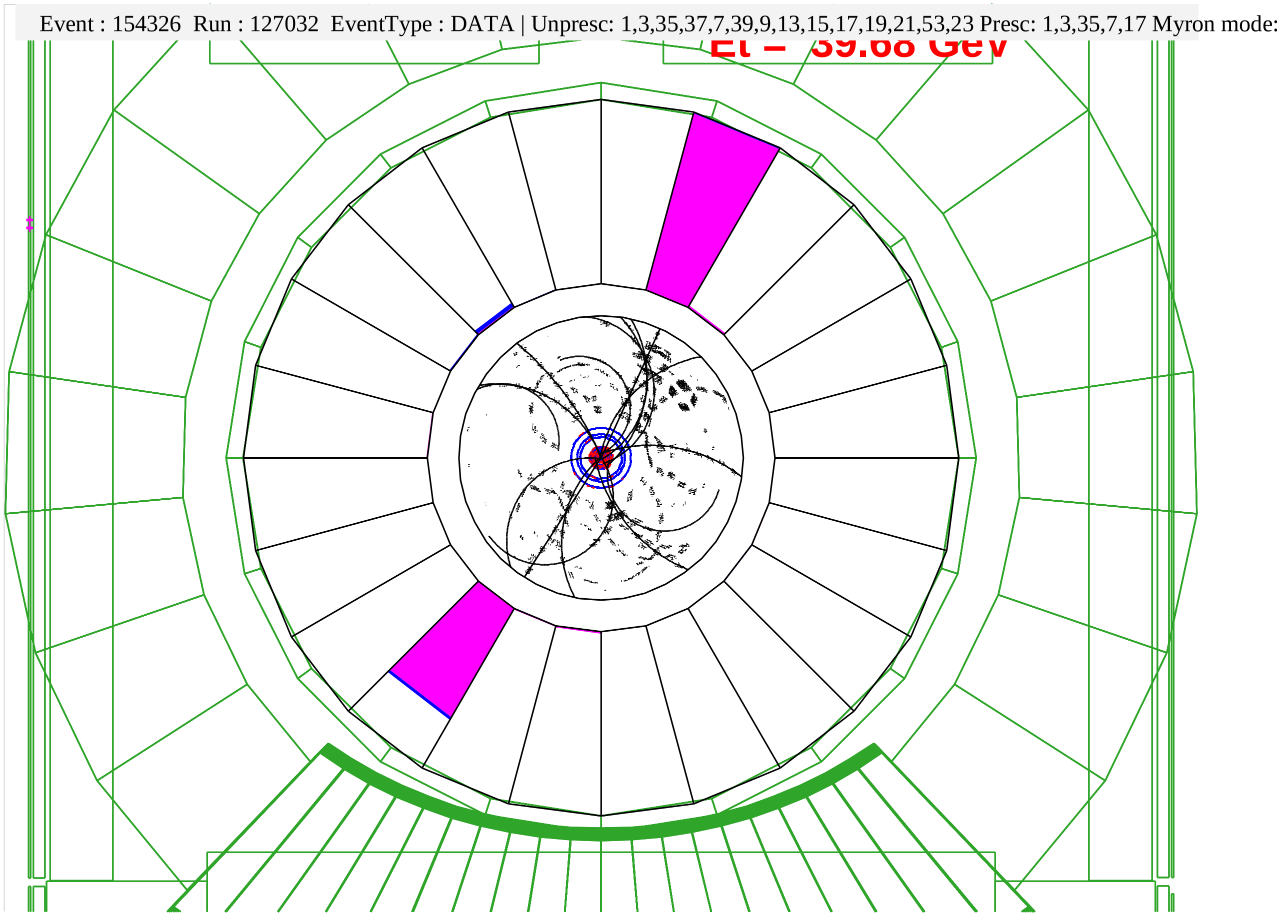


Figure 5: Z $\rightarrow e^+e^-$ decay candidate, RunII Data sample

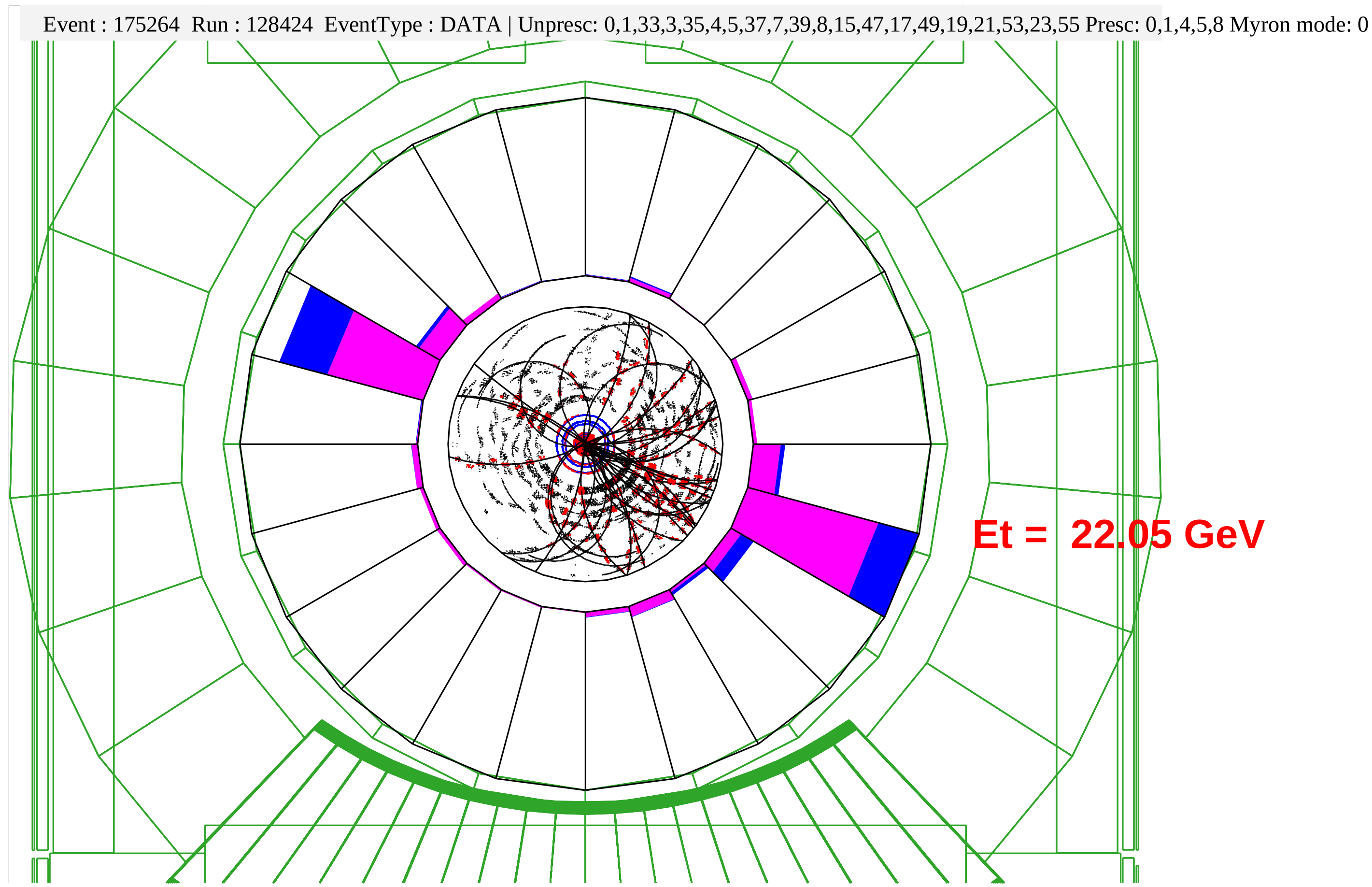


Figure 6: di-jet event candidate, RunII Data sample

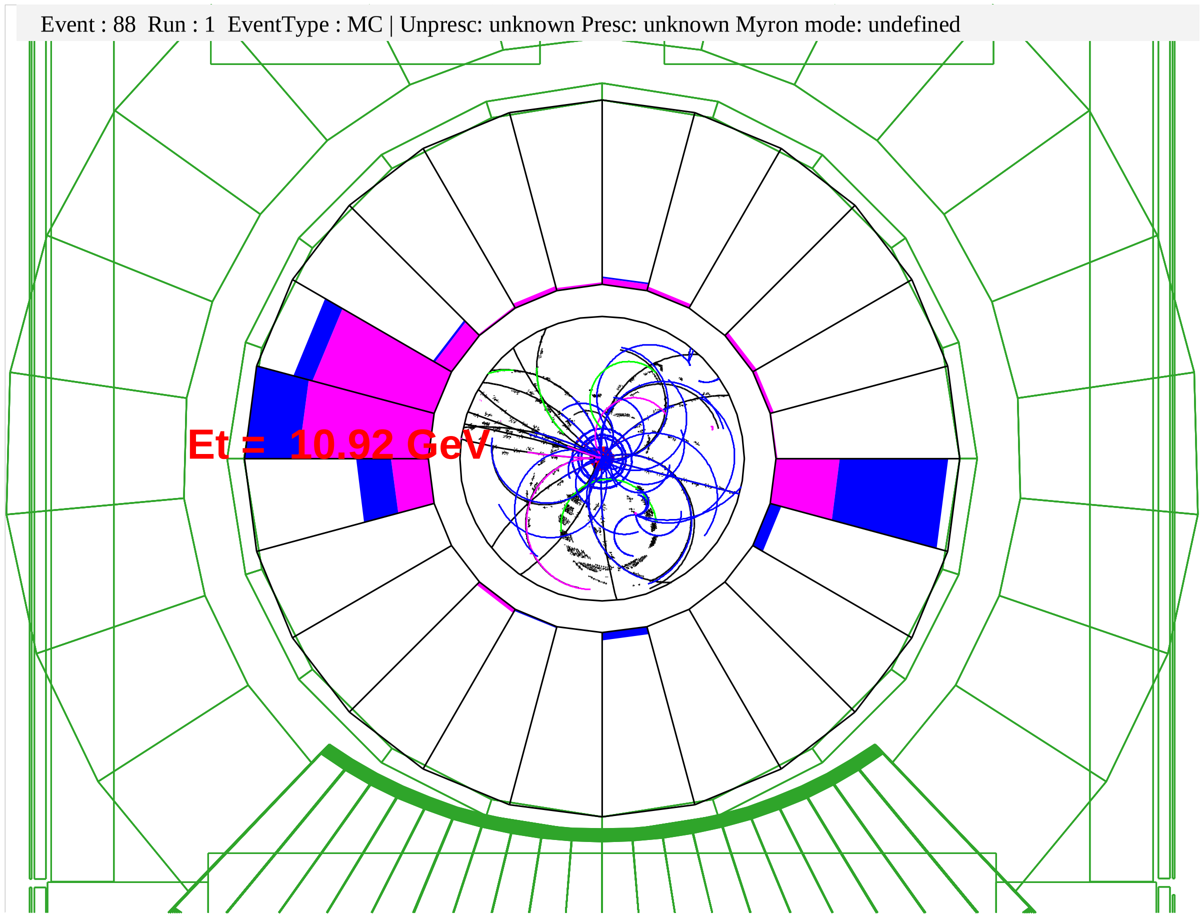


Figure 7: $Z \rightarrow \tau\bar{\tau}$ decay, MC sample generated by Pythia

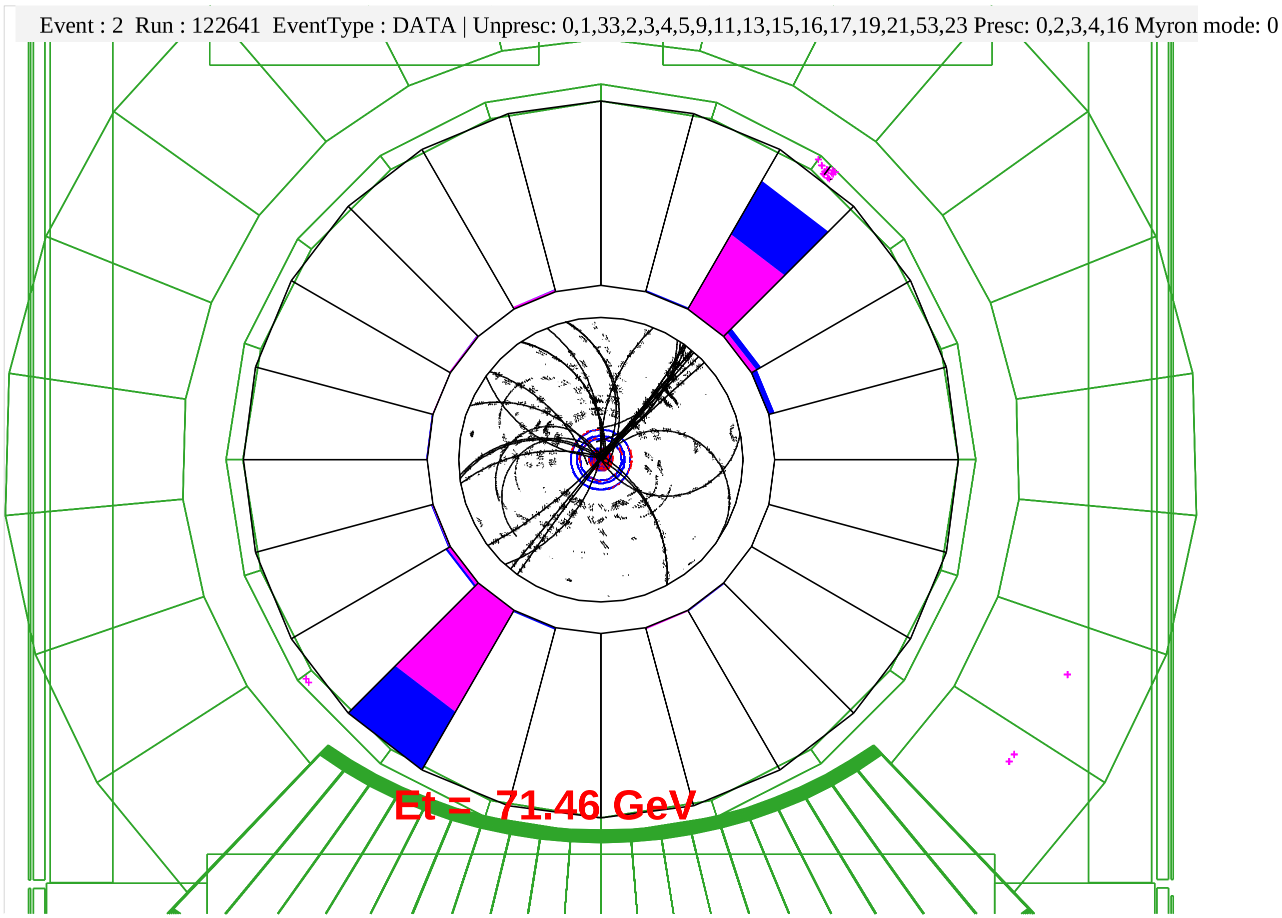


Figure 8: di-τ decay candidate, RunII Data sample

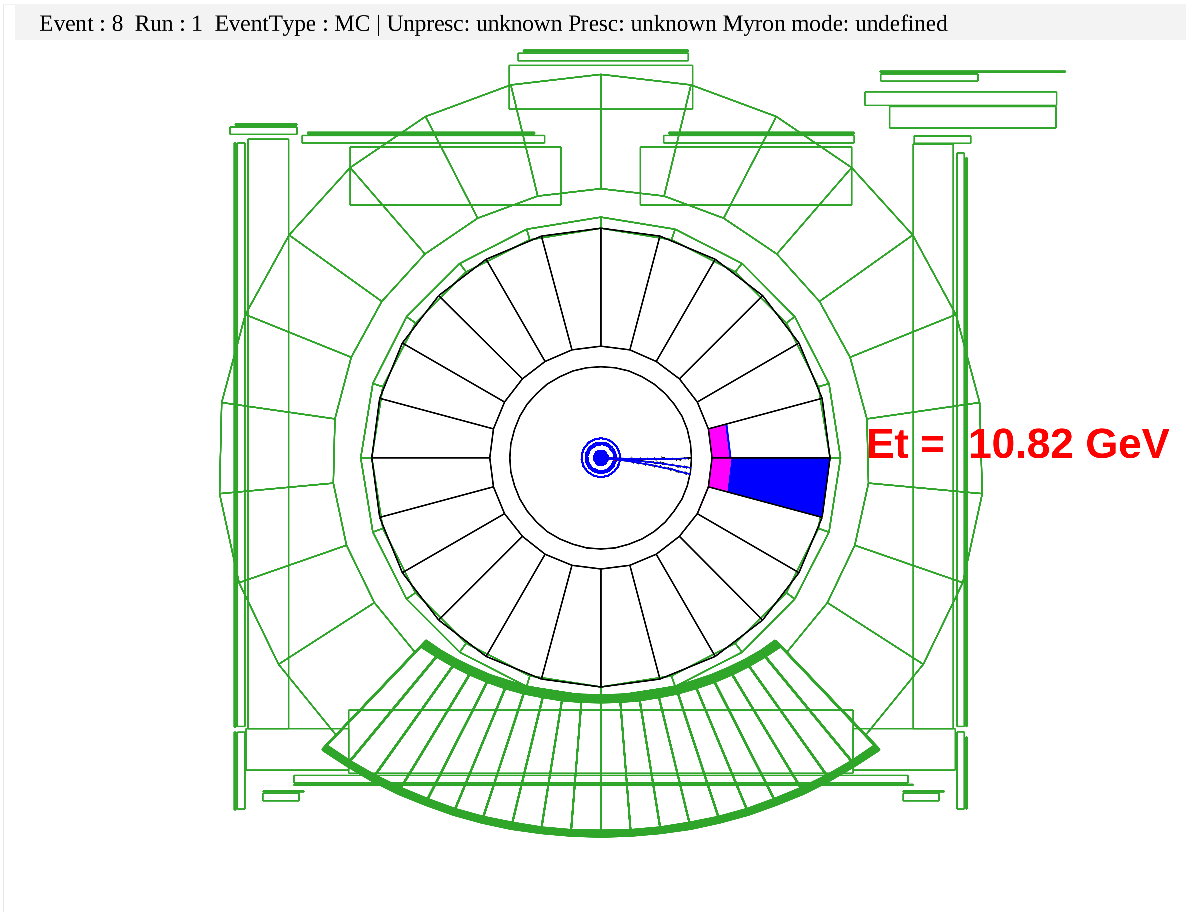


Figure 9: fake τ decays to three charged particles, MC sample, P_T = 30GeV

Monte Carlo Study of τ

- MC sample

  fake τ's generated by single particle gun

  Full simulations of detector response

  Selection criteria : used that of RunI

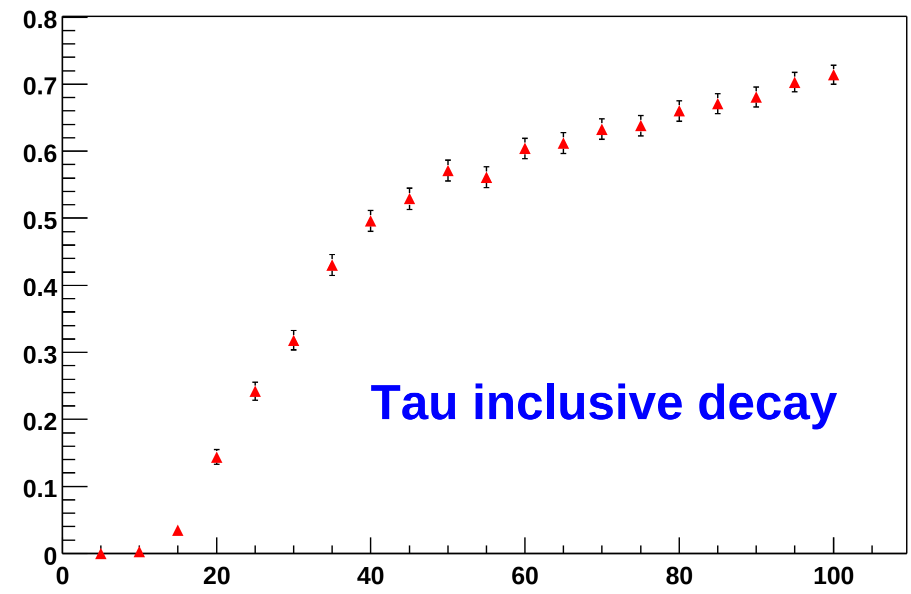
- τ finding efficiency

  A program, called TauFinderModule to select τ's

  Developed and maintained by Fedor Ratnikov, Rutgers postdoc.

  All analysis involving τ's will use this module

  The selection efficiency as a function of P_T



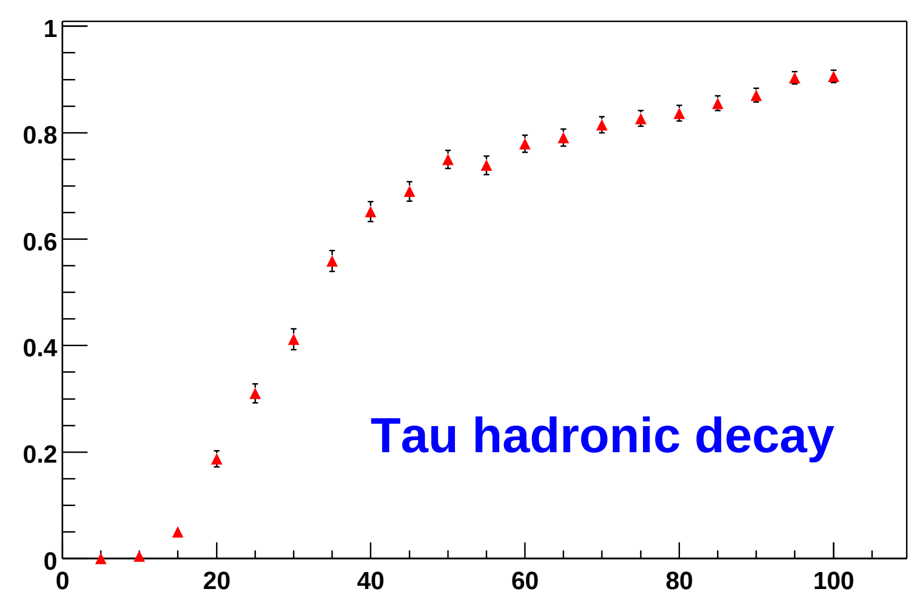


Figure 10: *tau* Chirality +1; efficiency as a function of P_T

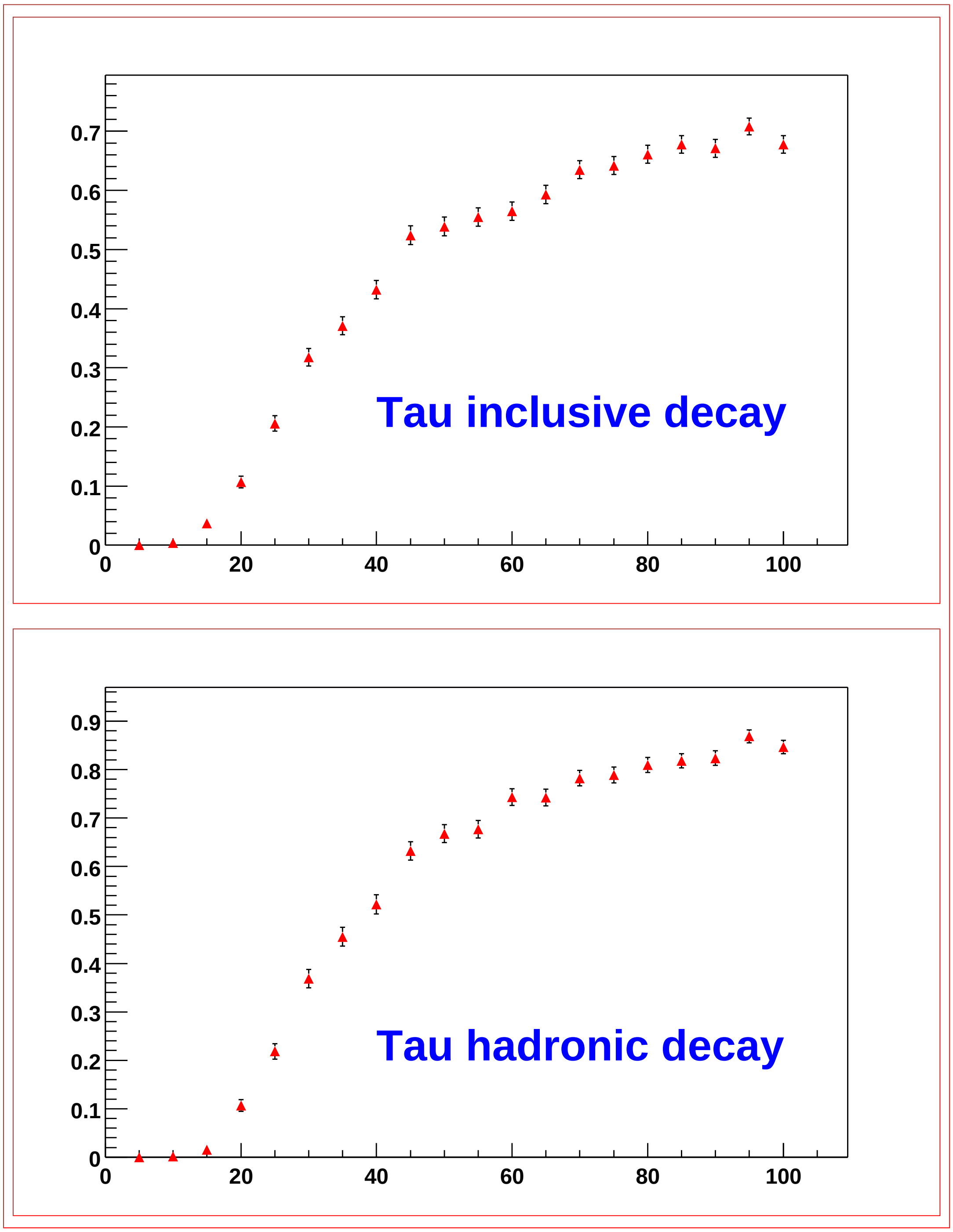


Figure 11: *tau* Chirality -1; efficiency as a function of P_T

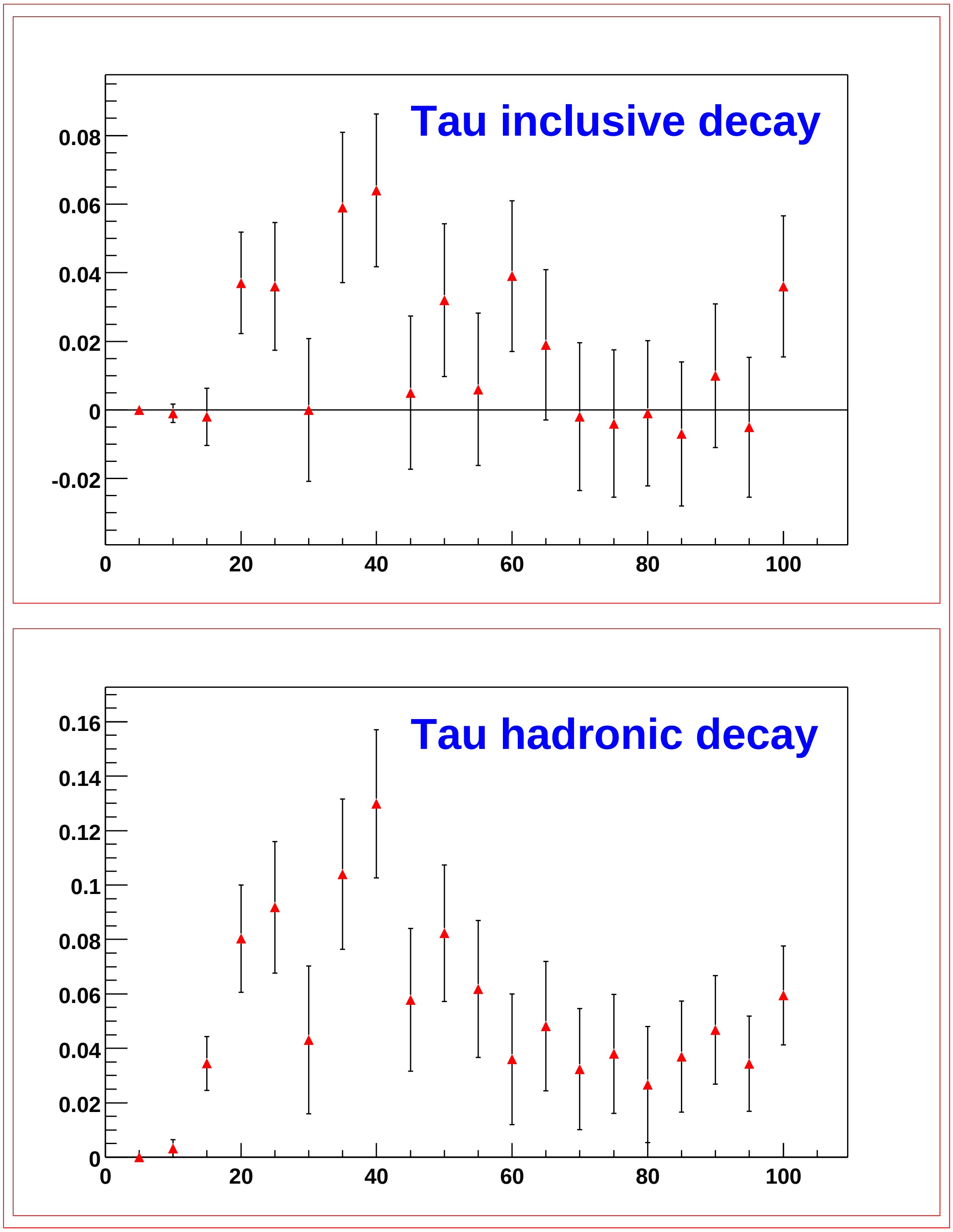


Figure 12: *tau* Chirality +1 - -1; difference of efficiency as a function of P_T

- Looking at $Z \to \tau\bar{\tau}$

  Interesting $H \to \tau\bar{\tau}$

  $Z \to \tau\bar{\tau}$ has similar signature

  Need for banchmarking and background study

- Neutrino reconstruction

  Using $\not{E}_T$ to reconstruct ν's four-momentum

  Assumption : ν's go along the direction of τ

$$E_\nu^1 sin\theta_1 cos\phi_1 + E_\nu^2 sin\theta_2 cos\phi_2 = \not{E}_x$$
$$E_\nu^1 sin\theta_1 sin\phi_1 + E_\nu^2 sin\theta_2 sin\phi_2 = \not{E}_y$$

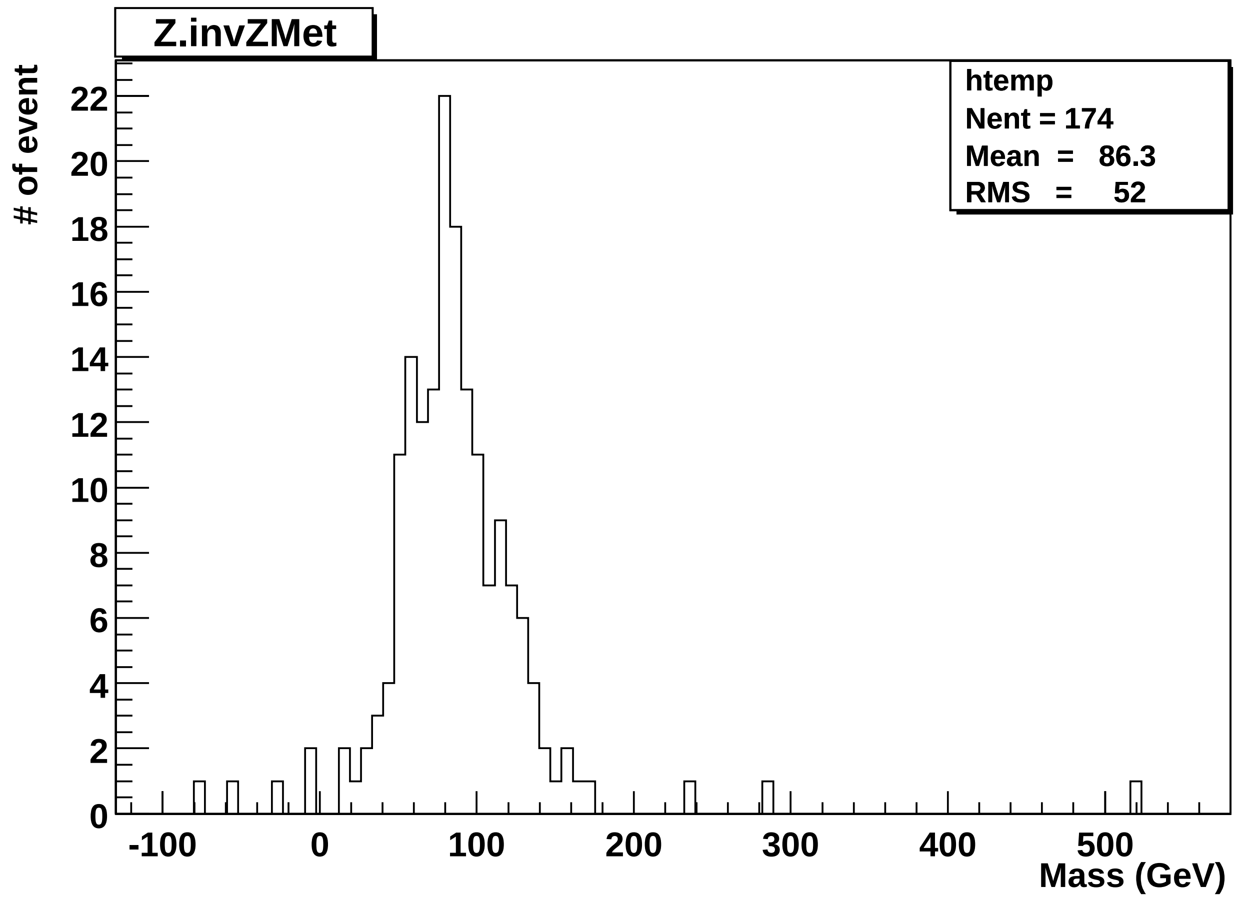


Figure 13: Invariant mass of expected Z

Plan for the next year

- Enhancing and maintaining EventMergeMods
- Continue the study of di-tau events

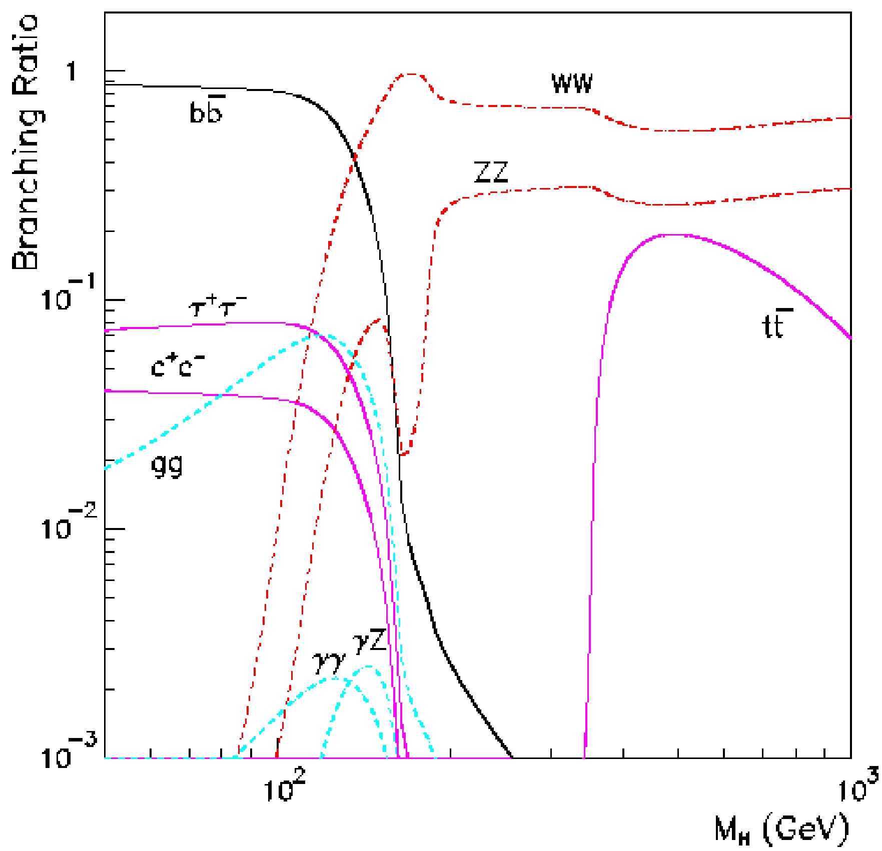


Figure 14: SM higgs decay channel

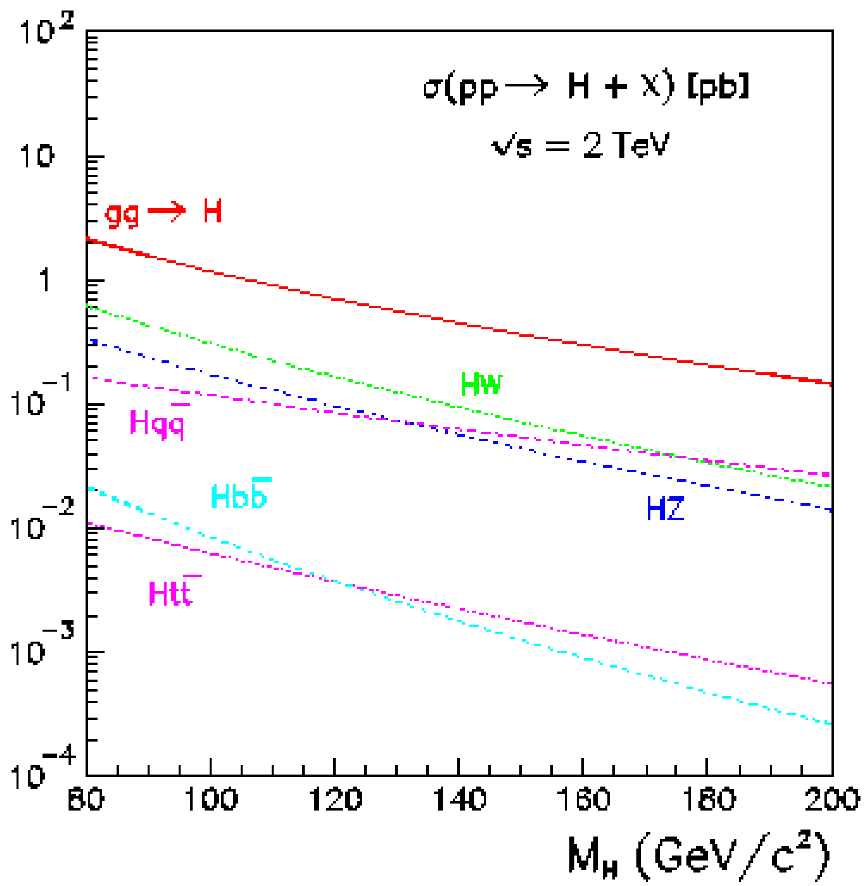


Figure 15: SM higgs cross section